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DUST RETENTION EFFICIENCIES OF DUSTFALL
COLLECTORS

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1957

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Presented at Golden Jubilee Meeting of
Air Pollution Control Association
June 4, 1957, St. Louis, Missouri

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DUST RETENTION EFFICIENCIES OF DUSTFALL COLLECTORS

Dustfall collection involves the use of containers often accommodating a small amount of liquid into which particles drop from the atmosphere. The wetting action of the liquid is intended to entrap the dust fall-out and prevents its re-entrainment by wind action. Water is customarily used because it readily permits subsequent analysis of the dust content. To retain effectiveness of water entrainment, it becomes necessary either to add anti-freeze in cold weather or to replace evaporation losses in warm weather.

Since dustfall collection usually involves a relatively large number of sampling sites scattered over a community area, an appreciable amount of time is required in visiting the sites to replenish the collectors with anti-freeze or water. Polyethylene containers require this attention only on the assumption that a wet bottom collector is superior to a dry bottom collector in dustfall retention. Collectors made of glass or other fragile material further require anti-freeze to prevent fracture by water freezing.

If the assumed superiority of the wet container should be insignificant, the time spent in servicing to maintain the liquid could be saved by using dry flexible collectors. Accordingly, this study was undertaken to investigate whether dry collection techniques which overcome the disadvantages of wet collection possess an equally high dust retention efficiency. One technique tested involves the use of a baffle designed to fit in the collector and prevent the formation of wind vortices that might

tend to sweep out the dust. The performance of dry collectors with and without baffles was evaluated in terms of their dust retention as compared to that of unbaffled wet collectors exposed simultaneously to the same field conditions. In addition to the relative efficiencies of dust retention, the performance test was designed to measure the absolute efficiency of each type of collector by "spiking" with a known weight of dust of such magnitude that the actual fall-out would be negligible in comparison.

TEST EXPERIMENT

An experiment was designed to evaluate the performance of the three types of collectors by simultaneous exposure to actual field conditions. It was set up on the roof of a seven-story laboratory building located in a residential area adjacent to some industry. The collectors were directly subject to winds from all sides excepting one which had a hillside overlooking the building. The experiment was conducted for five weeks in the fall and repeated in early spring. Each period included a number of days of rain which temporarily converted all the containers to wet collectors. A similar experiment is scheduled to be performed at the Southwest Research Institute in San Antonio, Texas, where extended periods of dry exposure can be maintained.

The polyethylene container* used throughout the study was cylindrical with a slight taper from top to bottom (Fig. 1), 10-3/4 inches in height and an opening diameter of 7-3/4 inches. The baffle used was constructed (Figs. 2 and 3) of vinylite plastic sheet (0.9 mm thick) and designed to match the taper of the container in such manner as to be clear of the bottom by about two inches and flush with the top.

* - Commercially available as bathroom waste baskets and manufactured by Plas-tex Corp., Los Angeles 64, Calif.

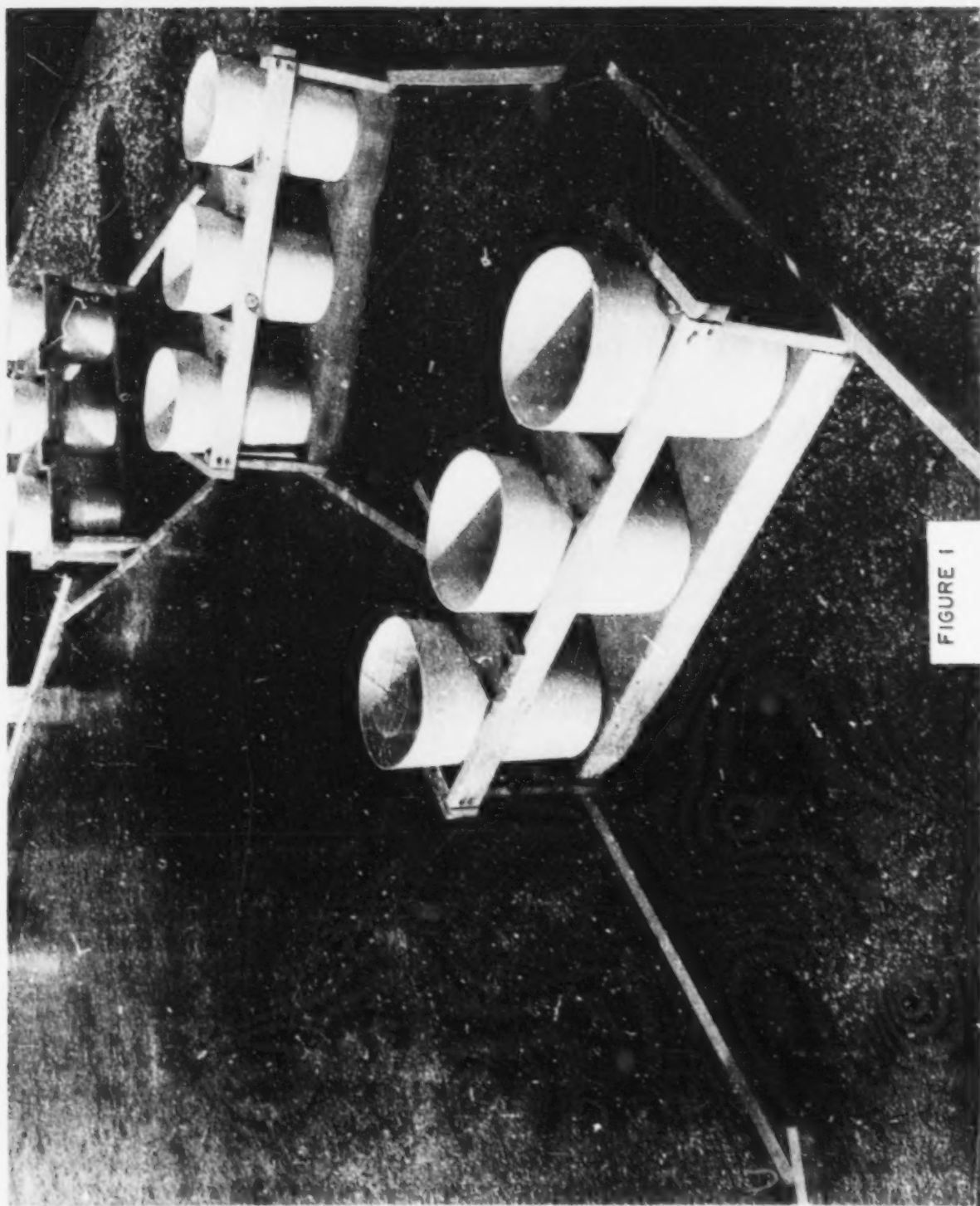


FIGURE 1

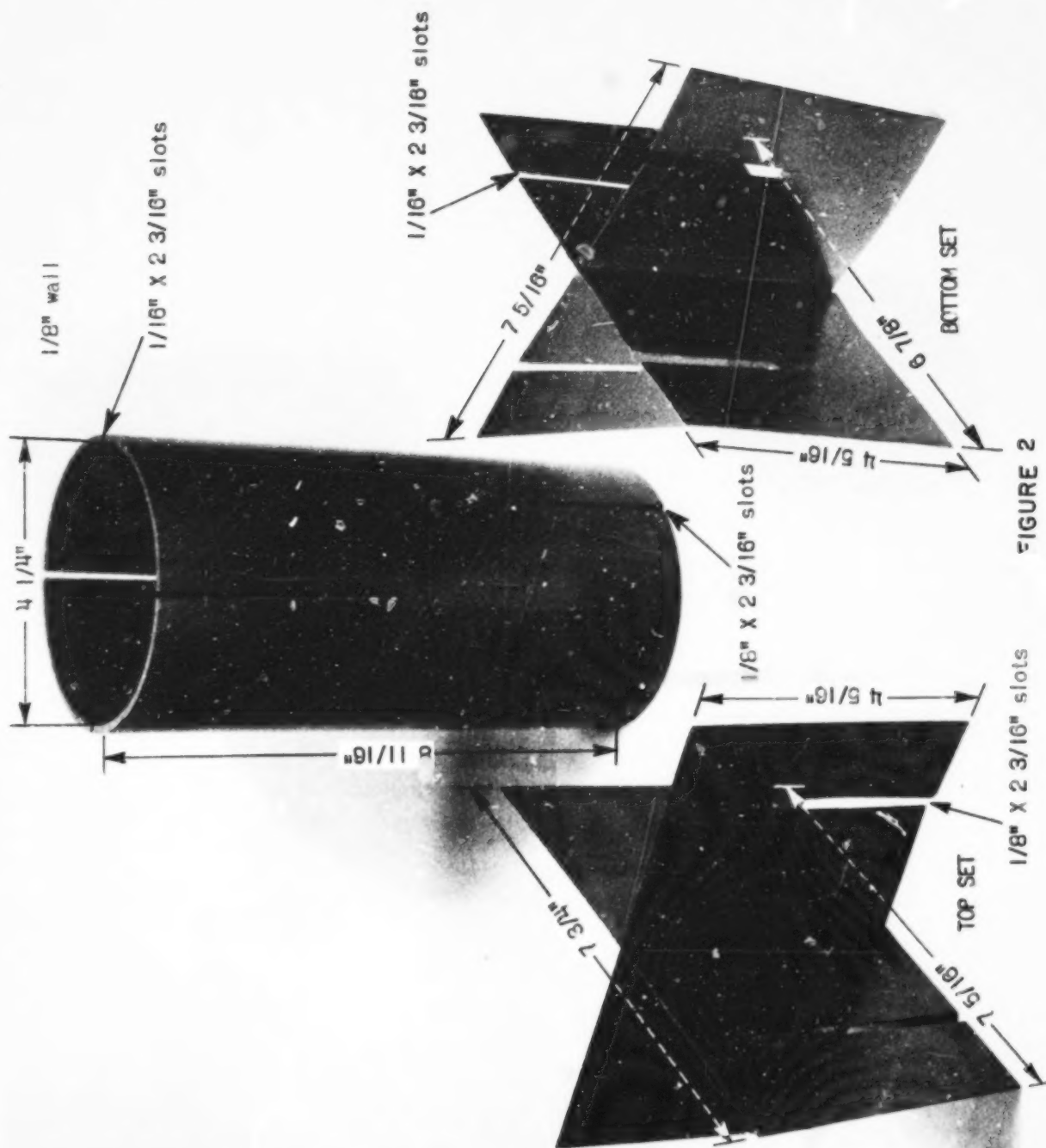


FIGURE 2

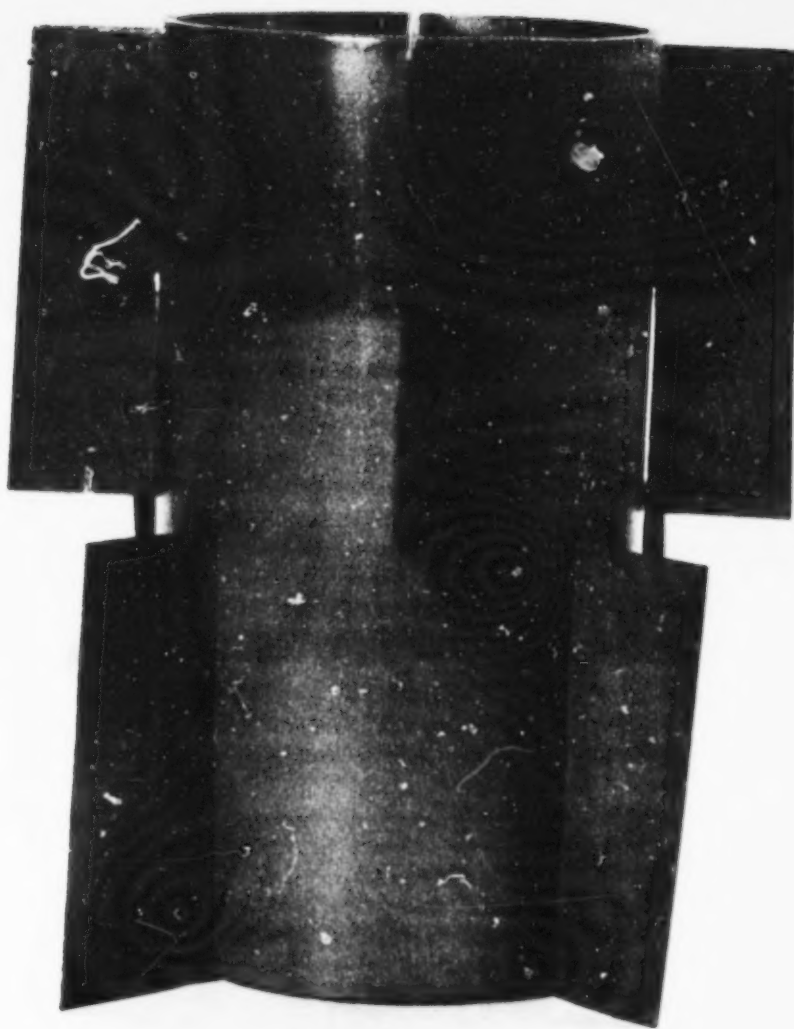


FIGURE 3

Wooden racks were used to prevent the collectors from being overturned or blown away by heavy winds. Initially, the racks did not have the wooden braces on the bottom and several were overturned. Each rack accommodated a set of three containers (Fig. 1) which represented each type being studied, namely, dry-bottom collection, wet-bottom collection, and dry-bottom collection with baffle. For statistical reasons, twelve of these sets were arranged in a circular pattern (Fig. 4) with the types of collectors randomly ordered within sets, a total of thirty-six containers. This arrangement allowed a statistical evaluation of bias on any set as a result of local meteorological effects near the edge of the roof.

Six of the sets were spiked with five grams of Fine Air Cleaner Test Dust* and the remaining six sets were left unspiked. The spiked and unspiked sets alternated in the circular arrangement. The wet-bottom collectors were set up initially with 500 ml of distilled water and were maintained wet with subsequent additions. During freezing conditions, ethyl alcohol was added as an anti-freeze. The dry-bottom collectors were not necessarily kept dry, but were subject to the existing weather.

GRAVIMETRIC ANALYSIS

Preliminary to the gravimetric analysis, the contents of each collector were screened for extraneous material, using a 20 mesh screen**. In both experiments the suspended solids were separated from the dissolved solids by filtration of the contents of the unspiked collector through a "Millipore" filter (type HA, 47 mm diam.). The filtrate evaporated to

* - Arizona road dust, sized and supplied by A. C. Spark Plug Division of General Motors.

** - Recommended Standard Methods for Continuing Dustfall Survey (APM 1-a) Air Pollution Control Association, Committee on Air Pollution Measurements.



FIGURE 4

partial dryness and the filtered solids were each dried to constant weight in an oven at 104°C. The measured net weight of the dissolved solids was combined with that of the suspended solids to give the total weight of solids.

In the case of the spiked collectors, a partial separation was made by centrifugation. A small amount by weight, consisting of very fine dust remained in the supernatant liquid. Since filtration of the supernatant liquid through a Millipore filter would be extremely slow because of the clogging properties of this fine suspension, the supernatant was not filtered but was taken to dryness in the same manner as the filtrate from the unspiked samples. In the spring trial, no attempt at separation was made and total solids for the spiked samples was determined by the direct evaporation procedure. Controls, consisting of two spiked collectors unexposed to atmospheric dustfall or wind action, were analyzed simultaneously to evaluate the efficiency of the procedure.

Fungus growth was mainly responsible in retarding filtration through the Millipore filter. Dry dust taken up in water just previous to filtration did not present the same problem. In the first experiment quaternary ammonium chloride was used as an algae inhibitor in an amount of 1 ppm by weight based on the anticipated maximum volume of water (one liter) that would be received in the collectors as a result of accumulated rainfall. The inhibitor was ineffective against fungus and some algae growth. In the second experiment, 0.5 ppm by weight of mercuric chloride was added but at this low concentration proved unsatisfactory.

DUSTFALL RETENTION

The difficulty encountered in the gravimetric analysis as a result of organic growth in the collectors presents a number of problems that warrant a separate investigation. If such growth is tolerated on the basis that no separation of solids is required, then there is a question of the gravimetric effects of such matter relative to actual dustfall. On the other hand, to suppress the growth, it will be necessary to select and apply a chemical that will serve as an appropriate toxicant to both algae and fungus when used at concentrations that would not be a health hazard if inadvertently consumed by humans or animals.

In the first experiment the loss of two sets each of the spiked and unspiked collectors due to high winds reduced the number of samples for analysis to four sets of each type. In the second experiment, however, the initial six sets of each type remained intact, providing data on all thirty-six collectors.

A statistical evaluation was made of the results of the gravimetric analysis (Table I). The weights of dust from a set of collectors of a given type are averaged to give a mean value. The standard deviation is expressed as a percentage of the mean.

The unspiked collectors, although limited in number, show a large percentage standard deviation primarily because they were sampling a dustfall which was light and random. The dry collector with a baffle, however, has a significantly lower deviation showing that the baffle tended to level out the random effects in sampling. This would indicate that individual sampling using a baffled collector will tend to be more representative statistically of the population mean.

TABLE I
DUSTFALL ANALYSIS DATA

COLLECTORS	EXPERIMENT 1			
	Unspiked		Spiked	
	Mean Wt. Mg	Std. Dev. %	Mean Wt. G	Std. Dev. %
Dry	114.	14	5.12	0.9
Wet	124.	12	5.05	1.5
Baffle	113.	5	5.06	0.9

COLLECTORS	EXPERIMENT 2			
	Unspiked		Spiked	
	Mean Wt. Mg	Std. Dev. %	Mean Wt. G	Std. Dev. %
Dry	161	15	4.94	1.5
Wet	158	28	4.88	0.9
Baffle	167	7	4.92	3.6

In the spiked collectors, the dustfall contribution is a small percentage of the total dust involved and the random effects of sampling are expected to contribute little to the deviation values. This is verified by the markedly lower percentage deviation values as compared to those for the unspiked collectors. When the mean values in both spiked and unspiked sets are compared and examined statistically, the result shows that there are no significant differences in the amounts of dust retained in the three types of collectors.

RETENTION EFFICIENCY

The efficiency of dust retention was calculated for each type of collector separately: in the unspiked collectors, it is the relative percentage ratio of the weight of dust in the baffled or unbaffled dry collector to that in the wet collector of the same set; in the spiked collectors, it is the absolute percentage ratio of the weight of dust in each collector to the composite weight of dust, consisting of the spiked dust and the dustfall given by the average mean weight of dust of the unspiked collectors. The relative and absolute percent efficiencies for a set of collectors of a given type were averaged to give corresponding mean values (Table II). The standard deviation is expressed as the difference from the mean.

A statistical evaluation of the mean values of dust retention efficiencies for both the spiked and unspiked samples shows no significant difference among the three types of collectors. The conclusions previously stated regarding the standard deviation of measured dustfall continue to hold for the calculated retention efficiencies.

TABLE II
DUST RETENTION EFFICIENCIES

COLLECTORS	EXPERIMENT 1			
	Unspiked		Spiked	
	Mean Eff. %	Std. Dev.	Mean Eff. %	Std. Dev.
Dry	91.	4.	100.	0.9
Wet	100.	--	99.	1.5
Baffle	92.	15.	99.	0.9
	EXPERIMENT 2			
	Unspiked		Spiked	
	Mean Eff. %	Std. Dev.	Mean Eff. %	Std. Dev.
Dry	112.	45.	99.	1.5
Wet	100.	--	98.	0.8
Baffle	111.	22.	99.	3.4

The conclusions are based on experiments in which the exposure of containers included windy and rainy weather (Tables III and IV). The total precipitation in the 16 days of the first experiment was 2.03 inches compared to 3.17 inches for the 21 days in the second experiment. The first experiment also had lower daily average as well as lower daily five-minute maximum wind speeds, although winds as high as 26 mph occurred. These weather data are fairly representative of fall and spring weather in a temperate climate. This study is being continued to include weather conditions representative of totally dry periods occurring in desert climate or in areas having dry summers.

Plastic containers have not been applied to dustfall collection to any appreciable extent, and it is possible that they have unsuspected superior dust retention because of their ability to become electrically charged. A study is being planned to investigate the effects of electrostatic charge build-up on the dust retention efficiency of polyethylene containers.

CONCLUSIONS

Dustfall collectors representing three collection techniques were exposed to atmospheric dustfall under weather conditions typical of a temperate climate. A statistical evaluation of the gravimetric analysis data and the dust retention efficiencies shows no significant differences among the three types of collections.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Eugene Jochem and Carl Berry for their assistance in the experiments and to Dr. E. K. Harris for his assistance on the statistical aspects of the problem.

TABLE III
WIND SPEED DATA

CUMULATIVE FREQUENCY DISTRIBUTION OF DAILY AVERAGE SPEEDS

	Experiment 1	Experiment 2
MPH	% Greater Than	% Greater Than
4	76	92
6	43	63
8	21	33
10	10	15

CUMULATIVE FREQUENCY DISTRIBUTION OF DAILY FIVE MINUTE MAX. SPEEDS

	Experiment 1	Experiment 2
MPH	% Greater Than	% Greater Than
8	80	89
10	56	74
12	36	58
14	20	42
16	8	30
18		20
20		13
22		9

TABLE IV
PRECIPITATION DATA

DISTRIBUTION OF PERIODS OF CONSECUTIVE RAINLESS DAYS

	Experiment 1	Experiment 2
Length of Period (Days)	Periods	Periods
1	3	2
2	0	2
3	1	0
4	2	0
5	0	2
6	1	0

DISTRIBUTION OF PERIODS OF CONSECUTIVE RAINY DAYS

	Experiment 1		Experiment 2	
Length of Period (Days)	Periods	Avg. Ppt..(in./day)	Periods	Avg. Ppt.(in./day)
1	3	0.13	2	0.08
2	2	0.10	1	0.03
3	0	--	1	0.37
4	1	0.26	2	0.05
5	1	0.04	0	--
6	0	--	1	0.24